

# What Are Earthquakes?

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- Where do most earthquakes happen?
- What makes an earthquake happen?
- What are seismic waves?

## What Is an Earthquake?

Have you ever been in an earthquake? An *earthquake* is a movement or shaking of the ground. Earthquakes happen when huge pieces of Earth's crust move suddenly and give off energy. This energy travels through the ground and makes it move. **Seismology** is the study of earthquakes. Scientists who study earthquakes are called *seismologists*.



### STUDY TIP

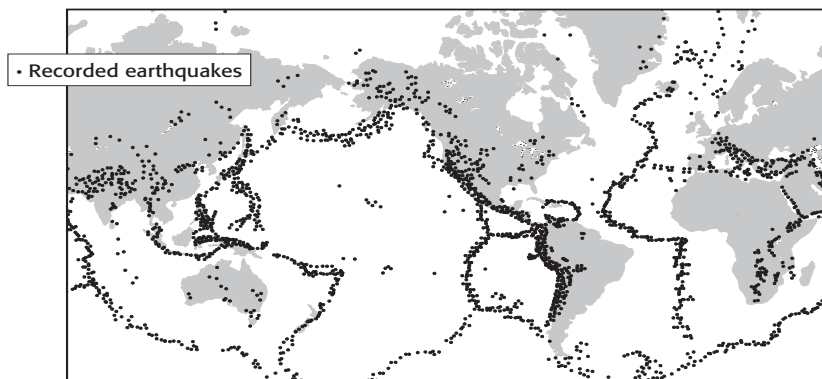
**Learn New Words** As you read this section, circle words that you don't understand. When you learn what they mean, write the words and their definitions in your notebook.

## Where Do Most Earthquakes Happen?

Most earthquakes happen at places where two tectonic plates touch. Tectonic plates are always moving. In some places, they move away from each other. In some places, they move toward each other. And in some places, they grind past each other.

The movements of the plates cause Earth's rocky crust to break. A place where the crust is broken is called a *fault*. Earthquakes happen when rock breaks and slides along a fault. ✓

### Earthquakes and Plate Boundaries



### READING CHECK

**1. Define** What is a fault?

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## TAKE A LOOK

**2. Infer** Use the earthquake locations to help you figure out where the tectonic plate boundaries are. Use a colored pen or marker to draw plate boundaries on the map.

**SECTION 1** What Are Earthquakes? *continued*

## Why Do Earthquakes Happen?

When tectonic plates move, pressure builds up on the rock near the edges of the plates. When rock is put under pressure, it changes shape, or deforms. This is called **deformation**.

Some rock can bend and fold like clay. When the pressure is taken away, the rock stays folded. When rock stays folded after the pressure is gone, the change is called *plastic deformation*.

### TAKE A LOOK

**3. Explain** How do you know that the rock layers in the figure were once under a lot of pressure?

**Folded Layers of Rock**



#### STANDARDS CHECK

**ES 1b** Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building result from these plate motions.

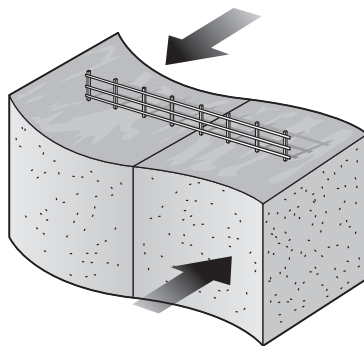
**Word Help: response**  
an action brought on by another action; a reaction

**Word Help: major**  
of great importance or large scale

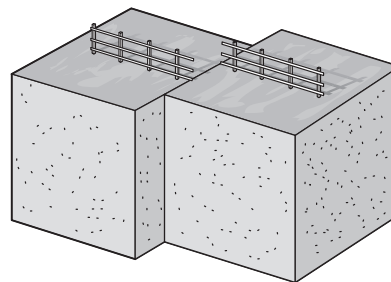
**4. Explain** How does the movement of tectonic plates cause earthquakes?

In some cases, rock acts more like a rubber band. It changes shape under pressure, but then it goes back to its original size and shape when the pressure goes away. This change is called *elastic deformation*.

Earthquakes happen when rock breaks under pressure. When the rock breaks, it snaps back to its original shape. This snap back is called **elastic rebound**. When the rock breaks and rebounds, it gives off energy. This energy creates faults and causes the ground to shake.



1. Forces push rock in opposite directions. The rock deforms elastically. It does not break.



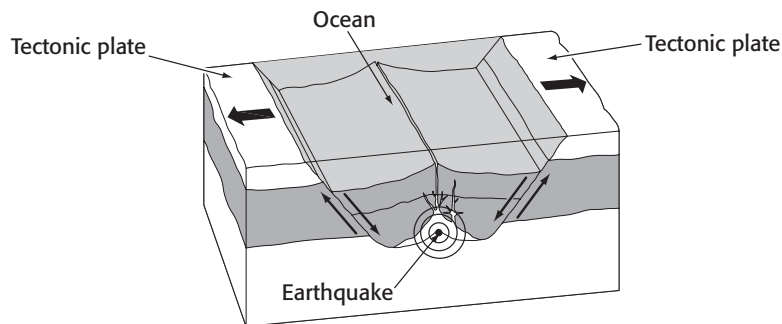
2. If enough force is placed on the rock, it breaks. The rock slips along the fault. Energy is released.

**SECTION 1** What Are Earthquakes? *continued*

## How Do Earthquakes Happen at Divergent Boundaries?

A *divergent boundary* is a place where two tectonic plates are moving away from each other. As the plates pull apart, the crust stretches. The crust breaks along faults. ✓

Most of the crust at divergent boundaries is thin and weak. Most earthquakes at divergent boundaries are small because only a little bit of pressure builds up before the rock breaks.

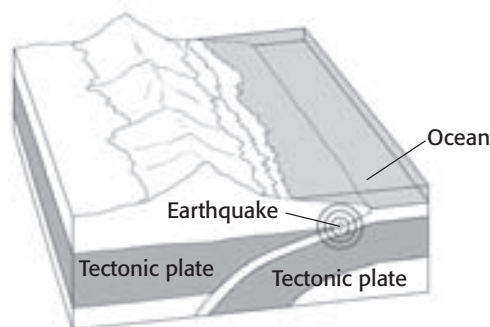


**Earthquakes at Divergent Boundaries**

## How Do Earthquakes Happen at Convergent Boundaries?

A *convergent boundary* is a place where two tectonic plates collide. When two plates come together, the rock is put under a lot of pressure. The pressure grows and grows until the rock breaks.

The earthquakes that happen at convergent boundaries can be very strong because there is so much pressure. The strongest earthquakes ever recorded have all happened at convergent boundaries. ✓



**Earthquakes at Convergent Boundaries**

✓ **READING CHECK**

**5. Define** What is a divergent boundary?

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### TAKE A LOOK

**6. Identify** Label the faults on the figure. Put a star where an earthquake is likely to happen.

✓ **READING CHECK**

**7. Explain** Why are many earthquakes at convergent boundaries very strong?

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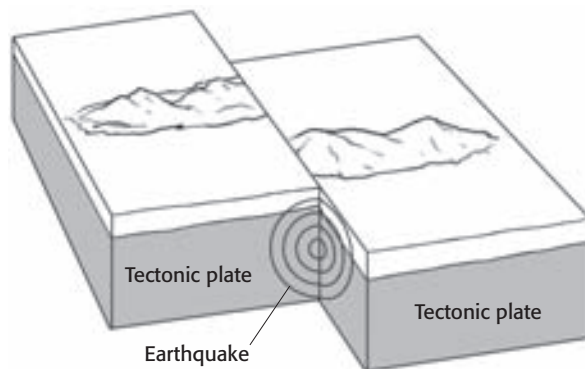
### TAKE A LOOK

**8. Identify** Draw arrows on the figure to show the directions that the two tectonic plates are moving.

**SECTION 1** What Are Earthquakes? *continued*

## How Do Earthquakes Happen at Transform Boundaries?

A *transform boundary* is a place where two tectonic plates slide past each other. As the plates move, pressure builds up on the rock. Eventually, the rock breaks and the plates slide past each other along a fault.



**Earthquakes at Transform Boundaries**

### TAKE A LOOK

**9. Identify** Draw arrows showing the directions that the tectonic plates in the figure are moving.

### Critical Thinking

**10. Apply Concepts** Why are most earthquake zones near plate boundaries?

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## What Is an Earthquake Zone?

A place where there are a lot of faults is called an *earthquake zone*. The San Andreas Fault Zone in California is an example of an earthquake zone. Most earthquake zones are near plate boundaries, but some are in the middle of tectonic plates.

## How Does Earthquake Energy Travel?

When an earthquake occurs, a lot of energy is given off. This energy travels through the Earth in the form of waves called **seismic waves**.

There are two kinds of seismic waves. *Body waves* are seismic waves that travel through the inside of Earth to the surface. *Surface waves* are seismic waves that travel through the top part of Earth's crust. ✓



### READING CHECK

**11. List** What are the two kinds of seismic waves?

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### BODY WAVES

There are two kinds of body waves: P waves and S waves. **P waves** are also called pressure waves. They are the fastest kind of seismic wave.

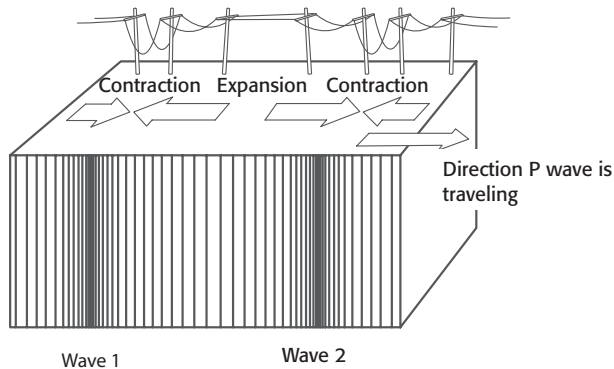
P waves can move through solids, liquids, and gases. When a P wave travels through a rock, it squeezes and stretches the rock. P waves make the ground move back and forth.

**S waves** are also called shear waves. S waves move rock from side to side. They can travel only through solids. S waves travel more slowly than P waves.

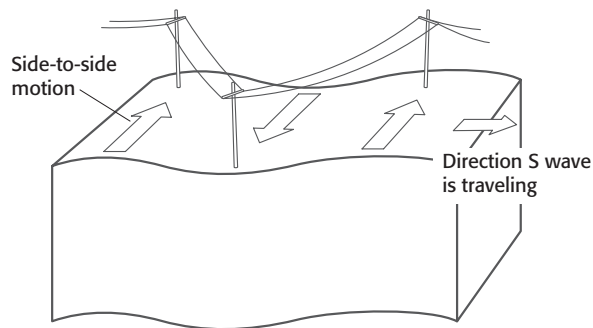
**SECTION 1** What Are Earthquakes? *continued***SURFACE WAVES**

Surface waves travel along the top of Earth's crust. Only the very top part of the crust moves when a surface wave passes.

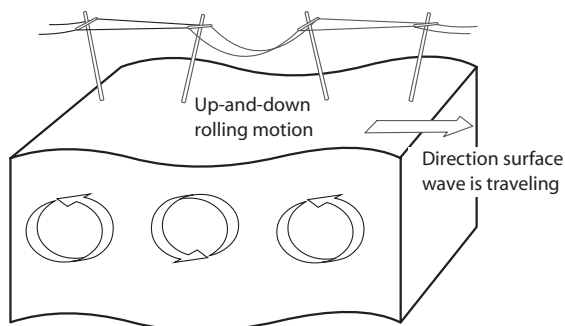
Surface waves travel much more slowly than body waves. When an earthquake happens, surface waves are the last waves to be felt. Surface waves cause a lot more damage to buildings and landforms than body waves do. ✓



**P waves** are body waves that squeeze and stretch rock.



**S waves** are body waves that can move rock from side to side.



**Surface waves** can move the ground up and down in a circular motion.

✓ **READING CHECK**

**12. Compare** Which kind of seismic wave travels the most slowly?

**TAKE A LOOK**

**13. Compare** How are the motions of P waves and S waves different?

**Critical Thinking**

**14. Infer** What do you think is the reason surface waves usually cause the most damage?

# Section 1 Review

NSES ES 1a, 1b

## SECTION VOCABULARY

**deformation** the bending, tilting, and breaking of the Earth's crust; the change in the shape of rock in response to stress

**elastic rebound** the sudden return of elastically deformed rock to its undeformed shape

**P wave** a seismic wave that causes particles of rock to move in a back-and-forth direction

**S wave** a seismic wave that causes particles of rock to move in a side-to-side direction

**seismic wave** a wave of energy that travels through the Earth, away from an earthquake in all directions

**seismology** the study of earthquakes

**1. Compare** What is the difference between an earthquake and a fault?

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**2. Identify** Where do most earthquakes happen?

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**3. Describe** What causes earthquakes?

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**4. Compare** What is the main difference between body waves and surface waves?

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**5. Apply Concepts** Why are some earthquakes stronger than others?

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**6. Infer** Why do few earthquakes happen in Earth's mantle?

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3. At transform boundaries, tectonic plates move past each other and produce shear stress.
4. Fault-block mountains form because of tensional stress. There is little tensional stress at transform boundaries.
5. the edge of the Pacific Ocean, where many volcanoes are found

## Chapter 5 Earthquakes

### SECTION 1 WHAT ARE EARTHQUAKES?

1. A fault is a break in the crust that rocks slide along.
2. The plate boundaries should be drawn along the areas with large numbers of earthquakes.
3. The rocks are folded.
4. The movement of the plates causes pressure to build up. When the pressure is released, an earthquake occurs.
5. a place where two tectonic plates are moving apart
6. The “fault” labels should be located at the places where the blocks slide past each other. Star should be somewhere along one of the faults.
7. A lot of pressure builds up before the rock breaks.
8. Arrows should be perpendicular to the plate boundary, pointing toward each other.
9. Arrows should be parallel to the fault, pointing in opposite directions; arrows should show the direction of displacement of each fault block.
10. Most earthquakes happen at plate boundaries.
11. body waves and surface waves
12. surface waves
13. P waves move particles back and forth, and S waves move them side to side.
14. Possible answer: All of their energy is released at the surface.

#### Review

1. Possible answers: An earthquake is a shaking or movement of the Earth, and a fault is a crack in the crust that rocks can slide on; earthquakes happen along faults.
2. Most earthquakes happen at tectonic plate boundaries.

3. Possible answers: Earthquakes happen when pressure builds up on a rock and it breaks; elastic rebound of rocks causes earthquakes.
4. Body waves travel through the Earth’s interior, but surface waves travel only on its surface.
5. The strength of an earthquake is directly related to the amount of pressure that builds up on the rock before it breaks. Some rocks are stronger than others, so more pressure builds up before the rock breaks. When a lot of pressure builds up, larger earthquakes happen.
6. Almost all earthquakes happen when rock breaks. The rock in the crust is brittle and breaks in response to stress. Rock in the mantle flows in response to stress.

### SECTION 2 EARTHQUAKE MEASUREMENT

1. The focus is the place where the rock breaks, and the epicenter is the point on the surface directly above the focus.
2. The epicenter should be marked directly above the focus, on the surface.
3. about 15 s
4. about 8,500 km
5. There should be a star at the place where all three circles intersect.
6. Possible answer: Seismologists look at the relative sizes of the different waves.
7. A magnitude 5.0 earthquake is 10 times stronger than a magnitude 4.0. A magnitude 6.0 is 10 times stronger than a 5.0. So, 10 times 10 makes it 100 times stronger.

#### Review

1. A seismograph is an instrument that measures ground movements. A seismogram is a tracing of ground movements, which is produced by a seismograph.
2. San Francisco is more likely to be an epicenter because it is near a plate boundary.
3. A time vs. distance graph can be used to measure how far away the epicenter is from different seismograph stations. Those distances can be used to make circles that overlap at the epicenter.
4. One seismogram tells you how far away the epicenter was and how strong the earthquake was. It doesn’t tell you which direction the waves came from.